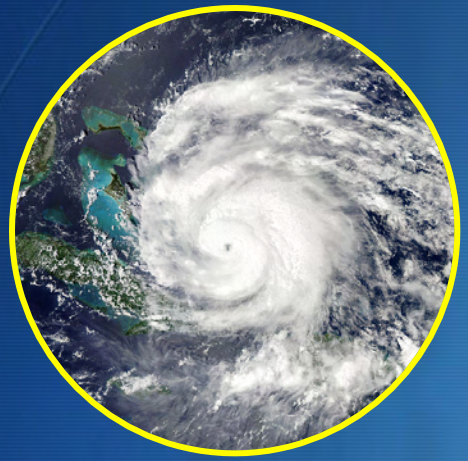
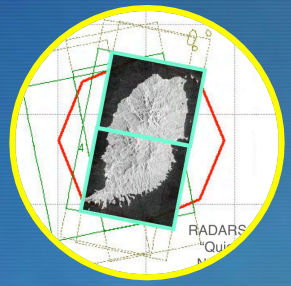
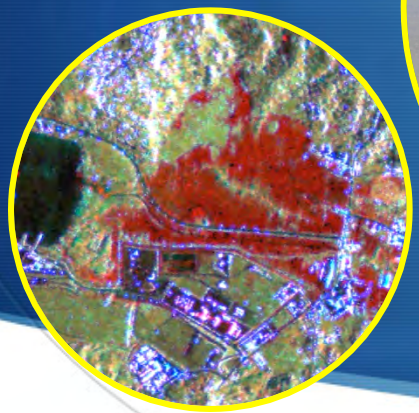






# Rapid and Detailed RADARSAT-2 Data Collection for the Caribbean Satellite Disaster Pilot (CSDP)

Practical Experience Gained During the Hurricane Season in 2010, 2011 and 2012

By

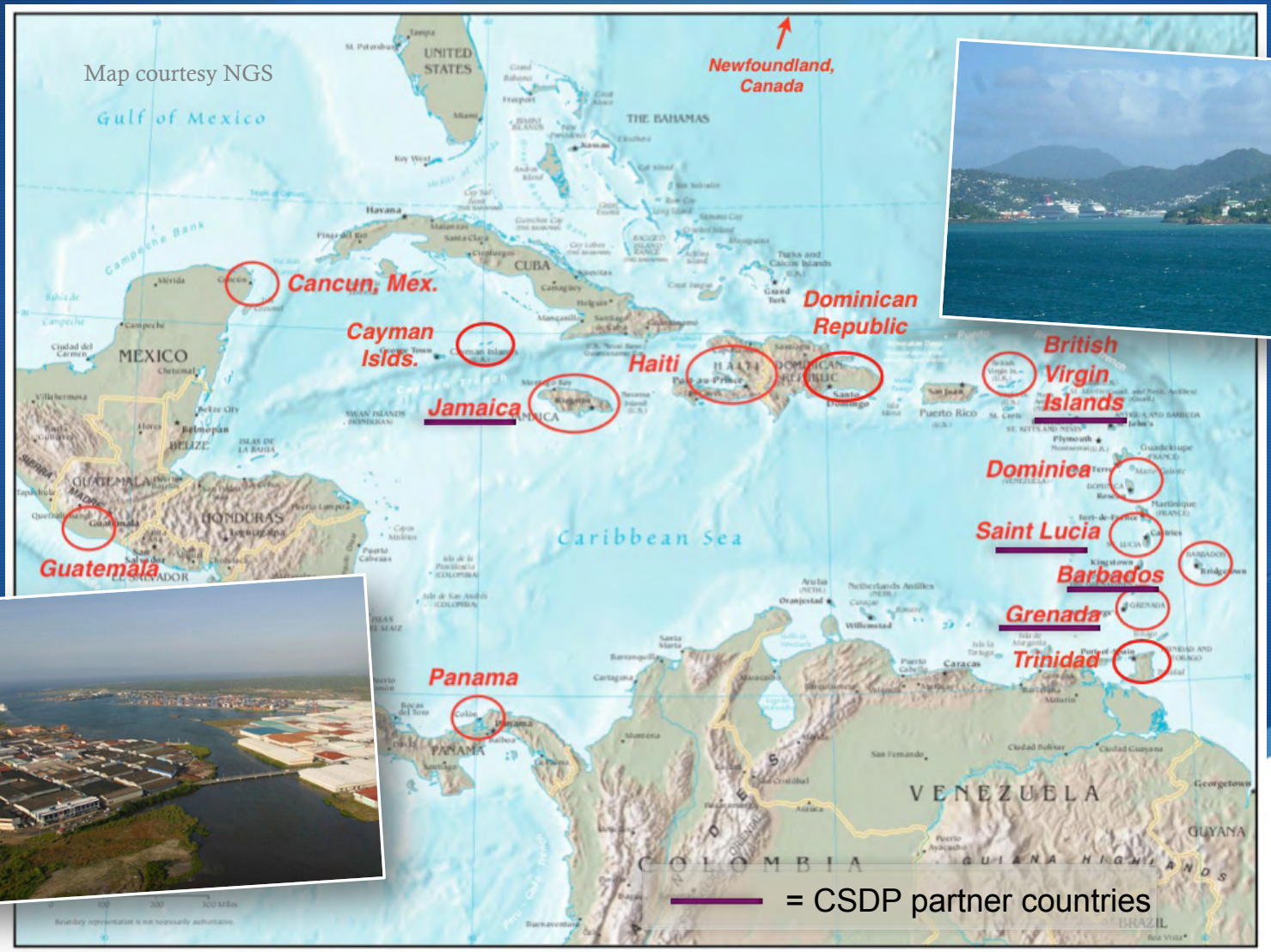
Dirk Werle (Ærde, Halifax, Canada)
Guy Aubé, Guy Séguin (CSA)
Stuart Frye (NASA/GSFC/SGT)

# Context, Goal and Objectives

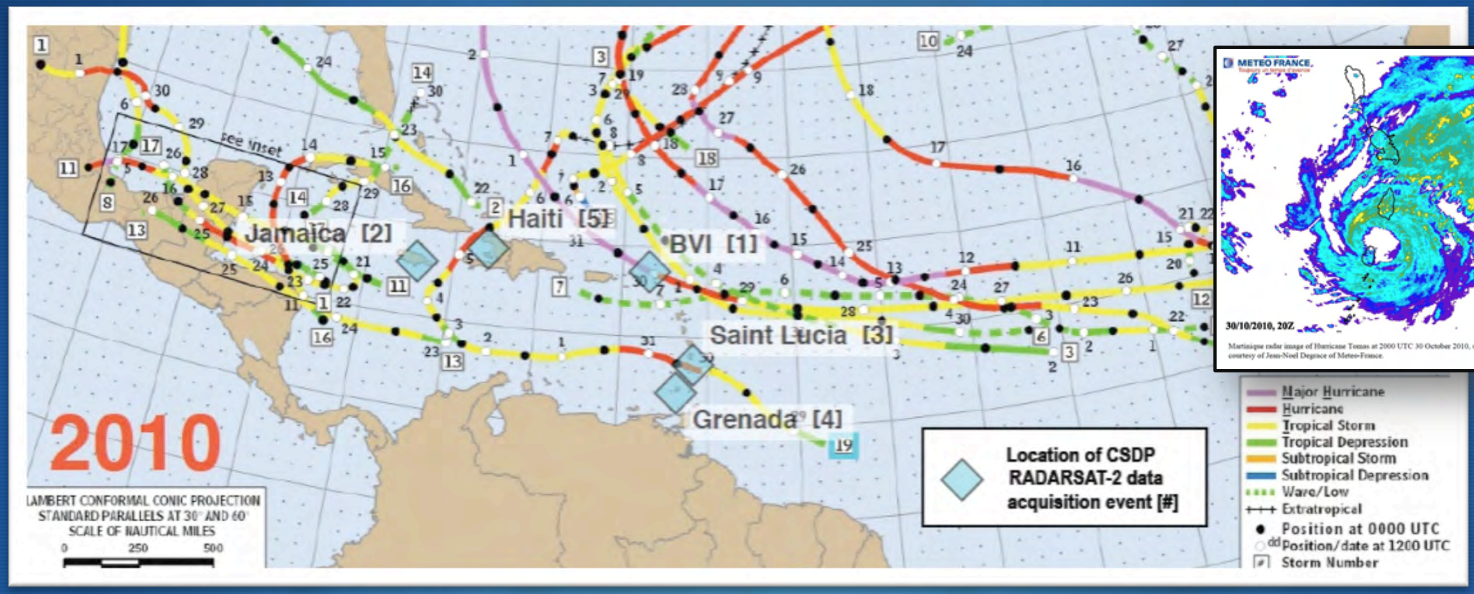
- Caribbean Satellite Disaster Pilot is a CEOS / GEO activity, regional *end-to-end* pilot, led by NASA, with CSA support
- Demonstration of RADARSAT-2 and other EO capabilities to assist disaster management; CDEMA, CIMH, UWI
- Rapid and detailed assessment of hurricanes and extreme rainfall events; geospatial information for damage analysis
- Timeliness is a critical issue: How well can RADARSAT-2 prepare and respond, especially to transient events?

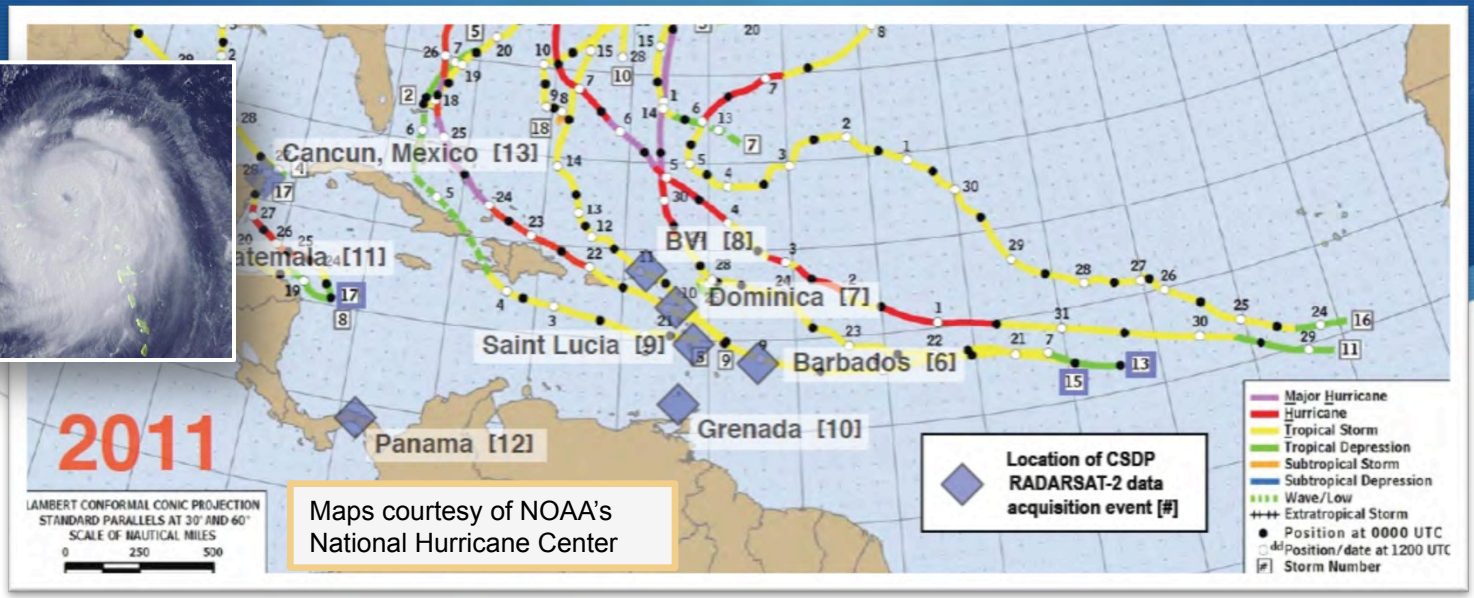
# Diverse CSDP Target Areas within the Caribbean

## Large Urban-Coastal Plains, Small Mountainous Island States

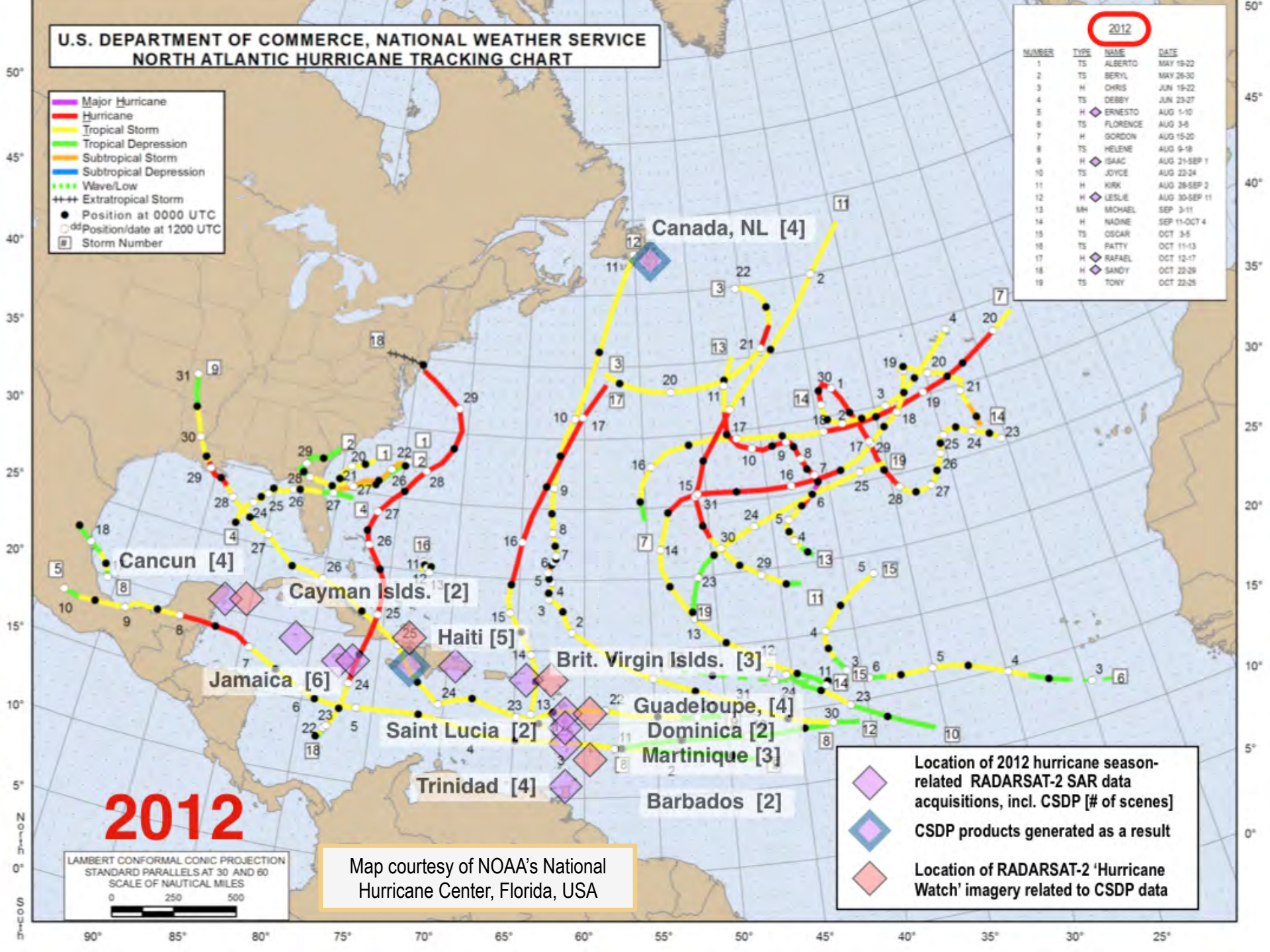



# Hurricane Track Maps and Location of CSDP Sites




Maps courtesy of NOAA's National Hurricane Center


U.S. DEPARTMENT OF COMMERCE, NATIONAL WEATHER SERVICE
NORTH ATLANTIC HURRICANE TRACKING CHART
Major Hurricane
Hurricane
Tropical Storm
Tropical Depression
Subtropical Storm
Subtropical Depression
Wave/Low
Extratropical Storm
Position at 0000 UTC
Position/date at 1200 UTC
Storm Number
2012
NUMBER TYPE NAME DATE
1 TS ALBERTO MAY 19-22
2 TS BERYL MAY 26-30
3 H CHRIS JUN 19-22
4 TS DEBBY JUN 23-27
5 H ERNESTO AUG 1-10
6 TS FLORENCE AUG 3-6
7 H GORDON AUG 15-20
8 TS HELENE AUG 9-18
9 H ISAAC AUG 21-SEP 1
10 TS JOYCE AUG 22-24
11 H KIRK AUG 28-SEP 2
12 H LESLIE AUG 30-SEP 11
13 MH MICHAEL SEP 3-11
14 H NADINE SEP 11-OCT 4
15 TS OSCAR OCT 3-5
16 TS PATTY OCT 11-13
17 H RAFAEL OCT 12-17
18 H SANDY OCT 22-29
19 TS TONY OCT 22-25
Canada, NL [4]
Cancun [4]
Cayman Islds. [2]
Haiti [5]
Jamaica [6]
Brit. Virgin Islds. [3]
Guadeloupe, [4]
Dominica [2]
Saint Lucia [2]
Martinique [3]
Trinidad [4]
Barbados [2]
2012
LAMBERT CONFORMAL CONIC PROJECTION
STANDARD PARALLELS AT 30 AND 60
SCALE OF NAUTICAL MILES
0 250 500
Location of 2012 hurricane season-related RADARSAT-2 SAR data acquisitions, incl. CSDP [# of scenes]
CSDP products generated as a result
Location of RADARSAT-2 'Hurricane Watch' imagery related to CSDP data
Map courtesy of NOAA's National Hurricane Center, Florida, USA

# RADARSAT-2 and other EO Data Collection

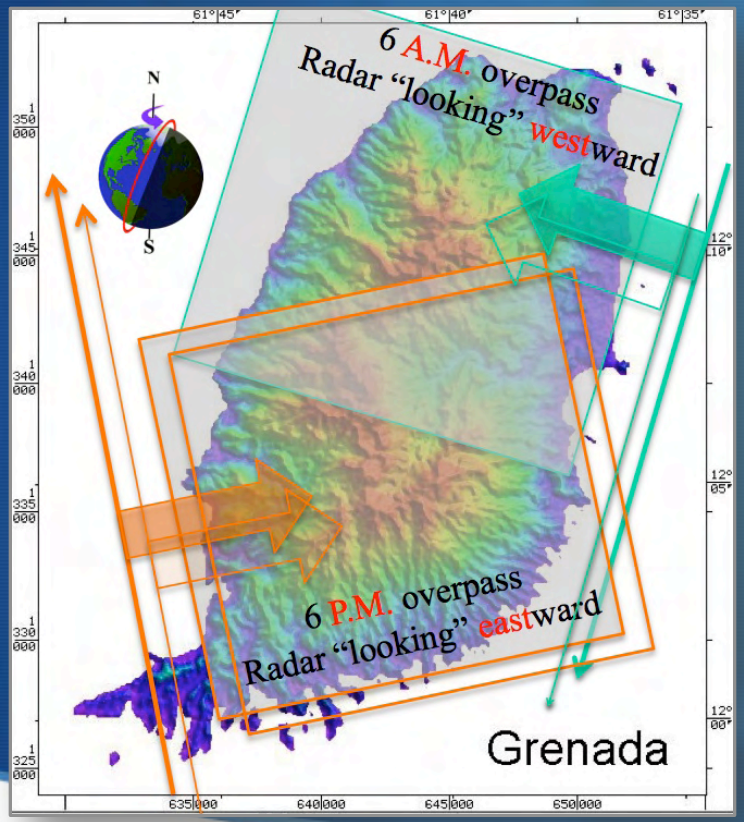
## Considerations for SAR data planning

- Pre-emptive preparatory SAR data acquisition (small areas)
- High-resolution RADARSAT-2 SAR data for small islands at different radar look directions
- Coordination with RADARSAT *Hurricane Watch* (large areas)

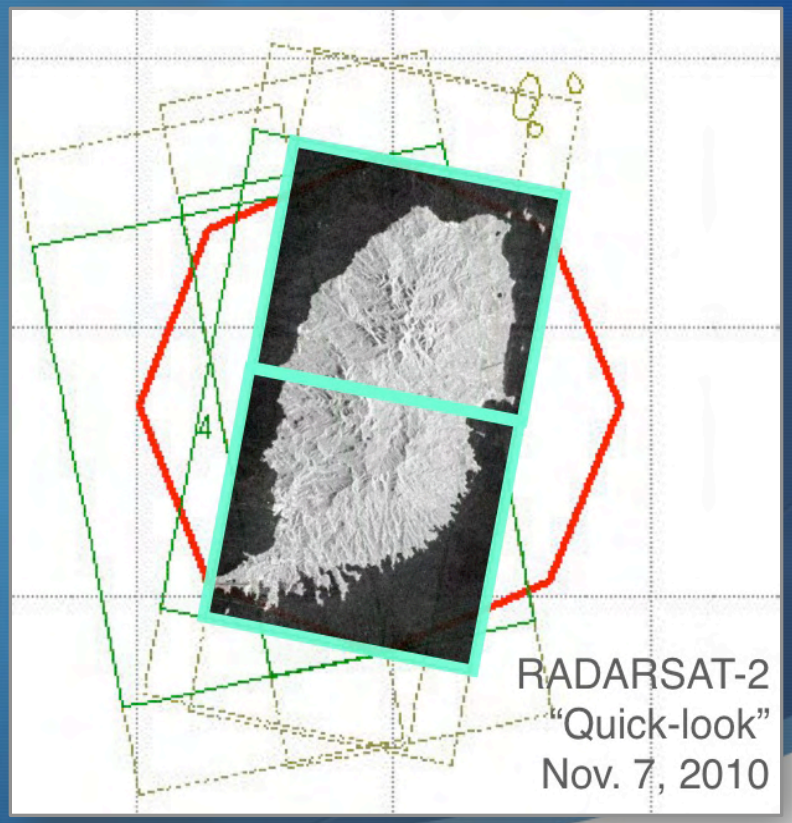
## Time-lines for SAR data acquisition and processing

- Data collection requests to be placed 24-48 hours in advance
- SAR data product delivery within hours of down-link
- Similar timelines for EO-1 ALI (via scheduling tool)
- Image maps in 1-5 days

# Pre-emptive RADARSAT-2 Data Acquisition *Before* Event for *Post*-Event Change Detection




Conceptual Design

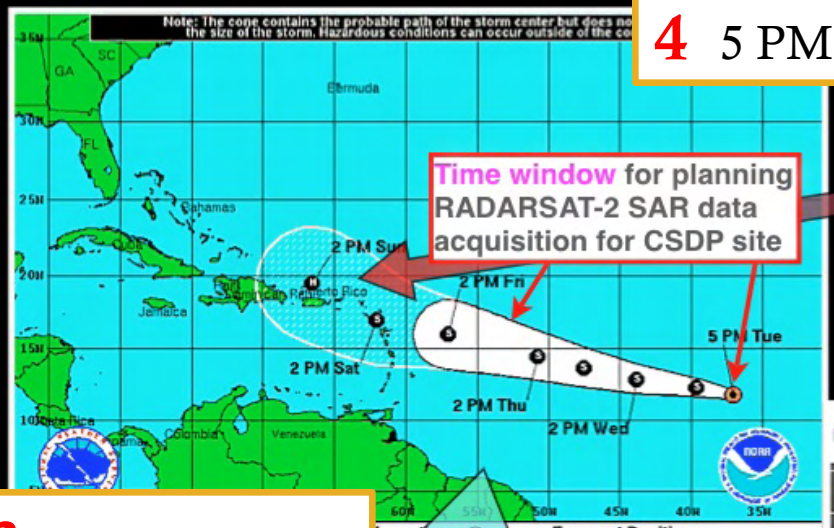


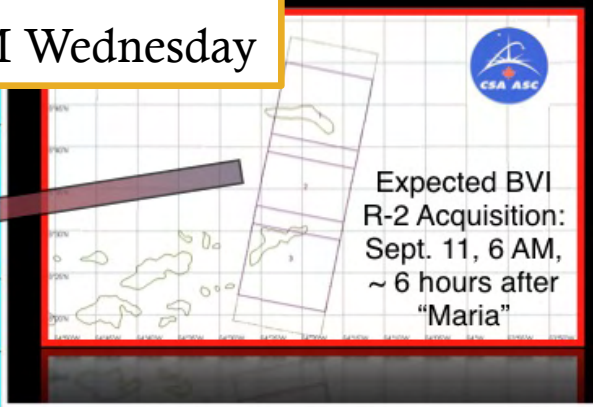

Actual Plan and Execution

**3 Plan** Option for R-2 data

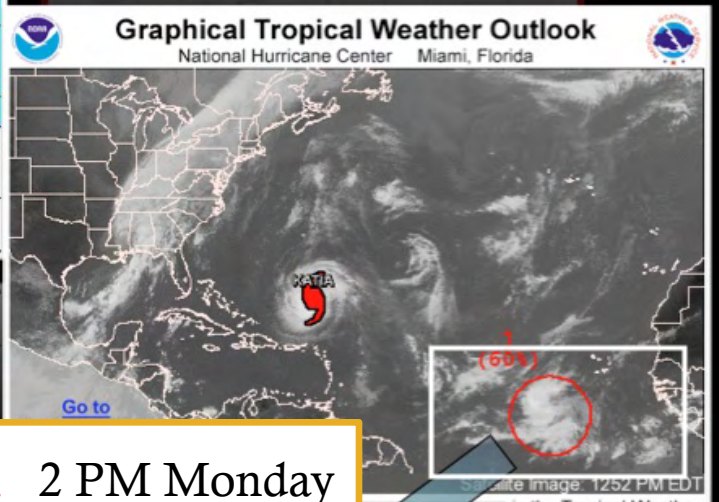
**4** 5 PM Wednesday

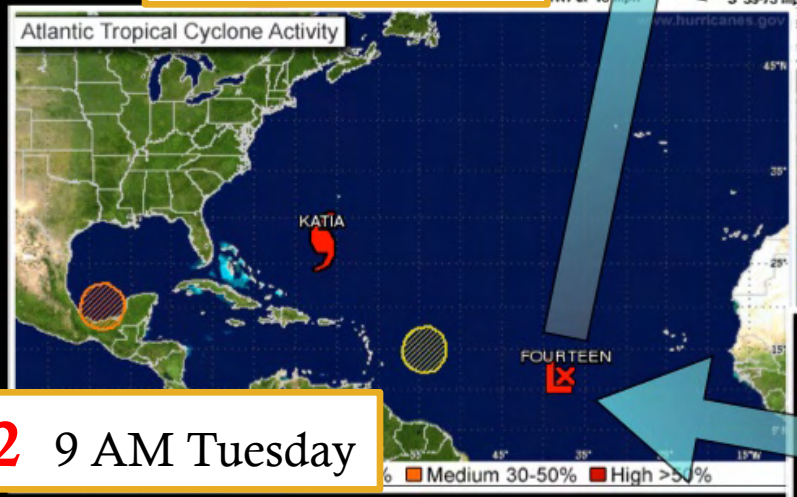
**4 Action** Request R-2 data for BVI



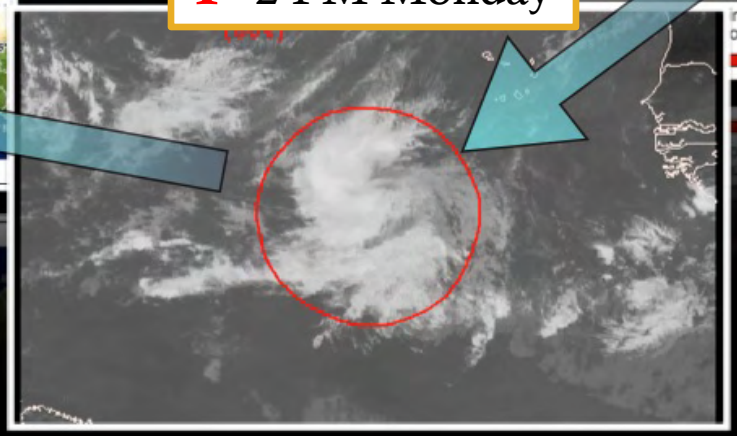




**3** 5 PM Tuesday




**1** 2 PM Monday



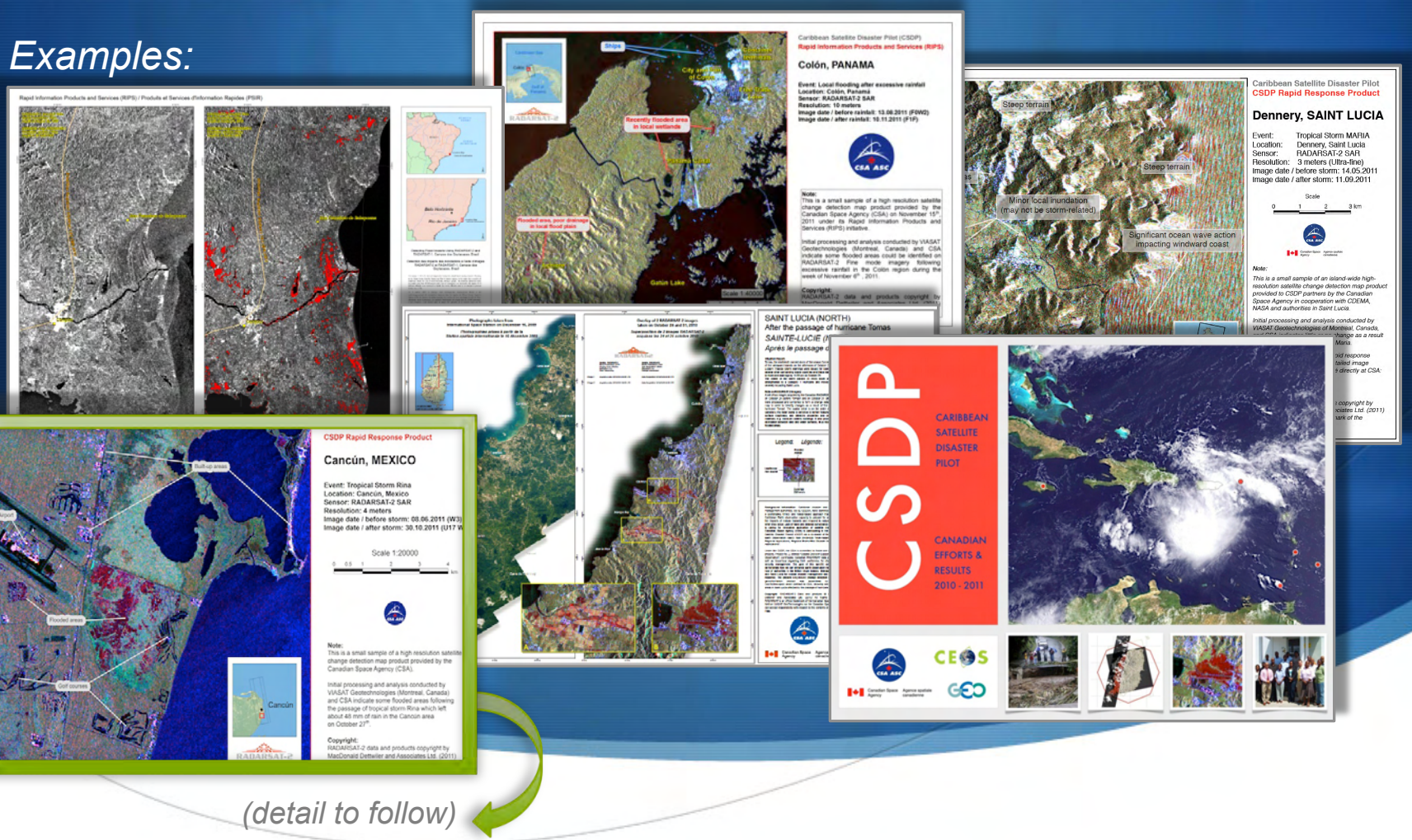
**2** 9 AM Tuesday

**1 & 2 Situational awareness:** nascent Hurricane "Maria" approaching the Caribbean

Forecast maps courtesy of NOAA, NHC

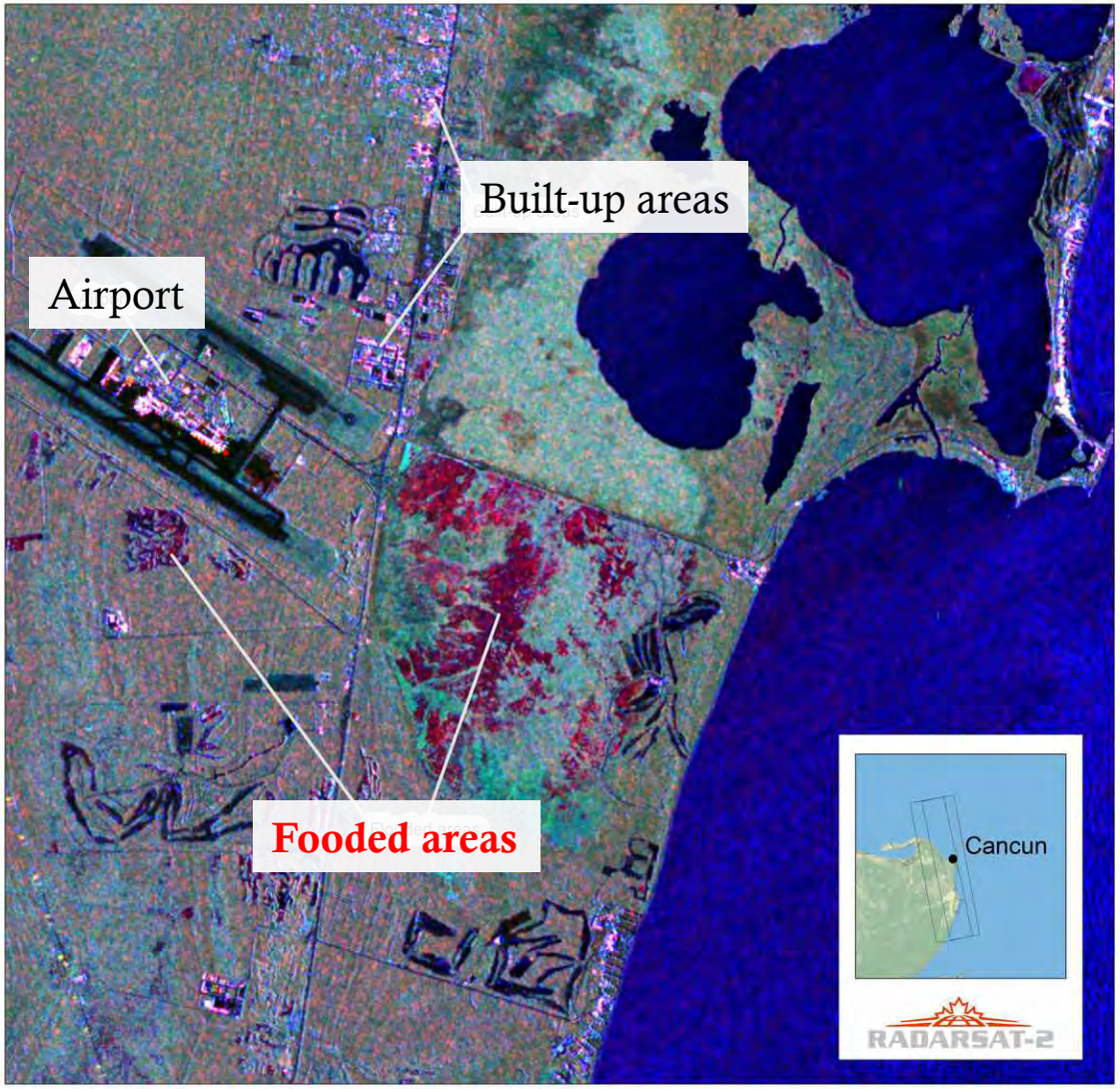
# ~25 Rapid Response RADARSAT Products Procured by CSA, with Canadian Industry, for CSDP Partners

*Examples:*



# Sample CSDP Rapid Response Product: Cancun

(Courtesy of CSA and Effigis GeoSolutions, RADARSAT data © MDA 2011)




Carribean Satellite Disaster Pilot

CSDP Rapid Response Product

## Cancun, MEXICO

**Event: Tropical Storm Rina**
**Location: Cancun, Mexico**
**Sensor: RADARSAT-2 SAR**
**Resolution: 4 meters**
**Image date / before storm: 08.06.2011 (W3)**
**Image date / after storm: 30.10.2011 (U17 W2)**

Scale 1:20000

0 0.5 1 2 3 4 km

**Note:**
This is a small sample of a high resolution satellite change detection map product provided by the Canadian Space Agency (CSA).

Initial processing and analysis conducted by VIASAT Geotechnologies (Montreal, Canada) and CSA indicate some flooded areas following the passage of tropical storm Rina which left more than 1300 mm of rain in the Cancun area on October 27th.

For more information on the rapid response RADARSAT-2 products and detailed image products contact Mr, Guy Aubé directly at CSA: guy-aube@asc-csa.gc.ca

# Summary of CSDP Results 2010/11/12

## High-res. RADARSAT-2 data collection

- More than 300 scenes collected
- Minor conflicts (resolved)
- SAR data collection successful; timely data product delivery
- "Before" and "after" SAR data for fast change detection

## Generation of rapid EO-based image map products

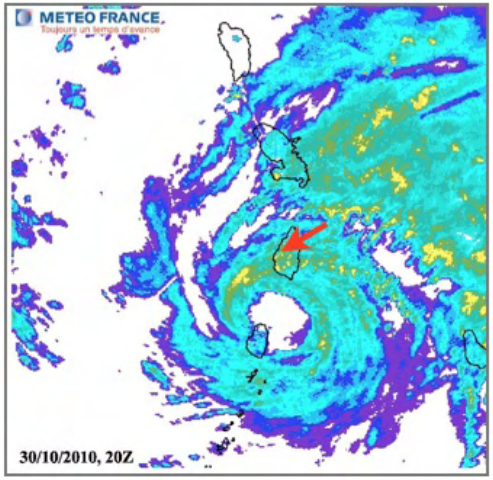
- Covered impact areas of 15 hurricanes, storms, severe rain
- Used hi-res optical (EO-1) as well as FNMOC satellite info
- CSA and partners generated more than 20 rapid response change detection image maps

# Change Detection: Flooded terrain, Saint Lucia

ISS photography,
*before* Hurricane Tomas


RADARSAT-2 SAR Ultra-fine,
*6 days before* Hurricane Tomas

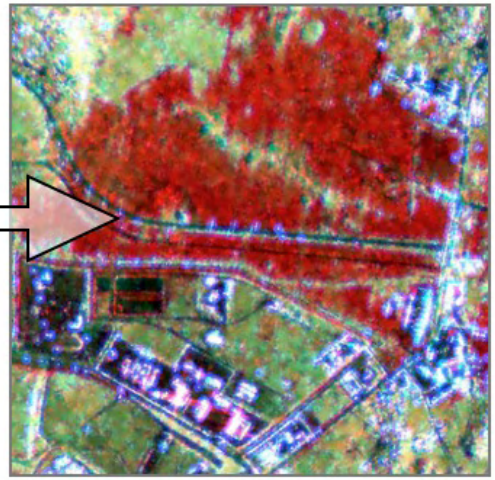
Ground-based rain radar,
*during* Hurricane Tomas





Ground photograph,
flooding in progress

RADARSAT-2 SAR Ultra-fine,
2 days *after* Hurricane Tomas



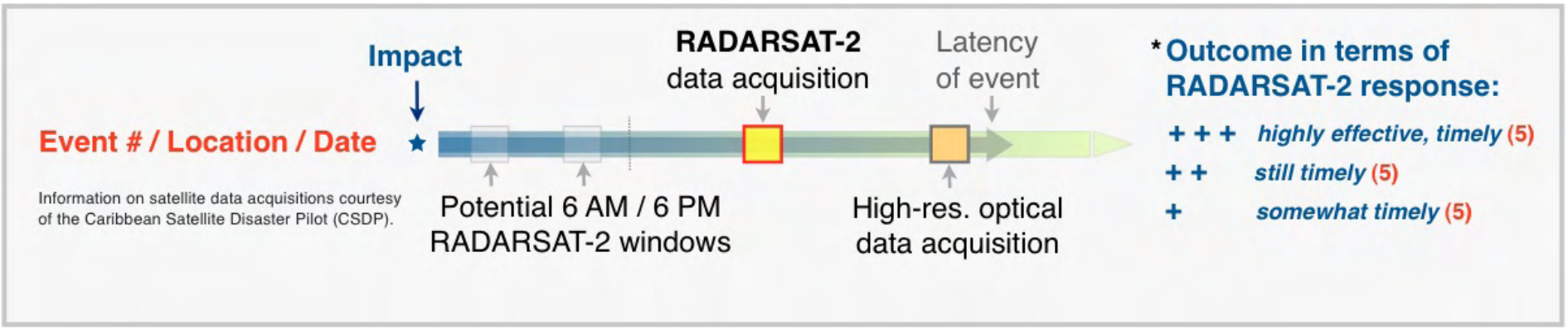
SAR change detection image
*before / after* HurricaneTomas



ISS Photo courtesy NASA; SAR processing courtesy of ViaSat/Effigis; RADARSAT-2 data © MDA; Ground photo courtesy NEMO, St. Lucia

12

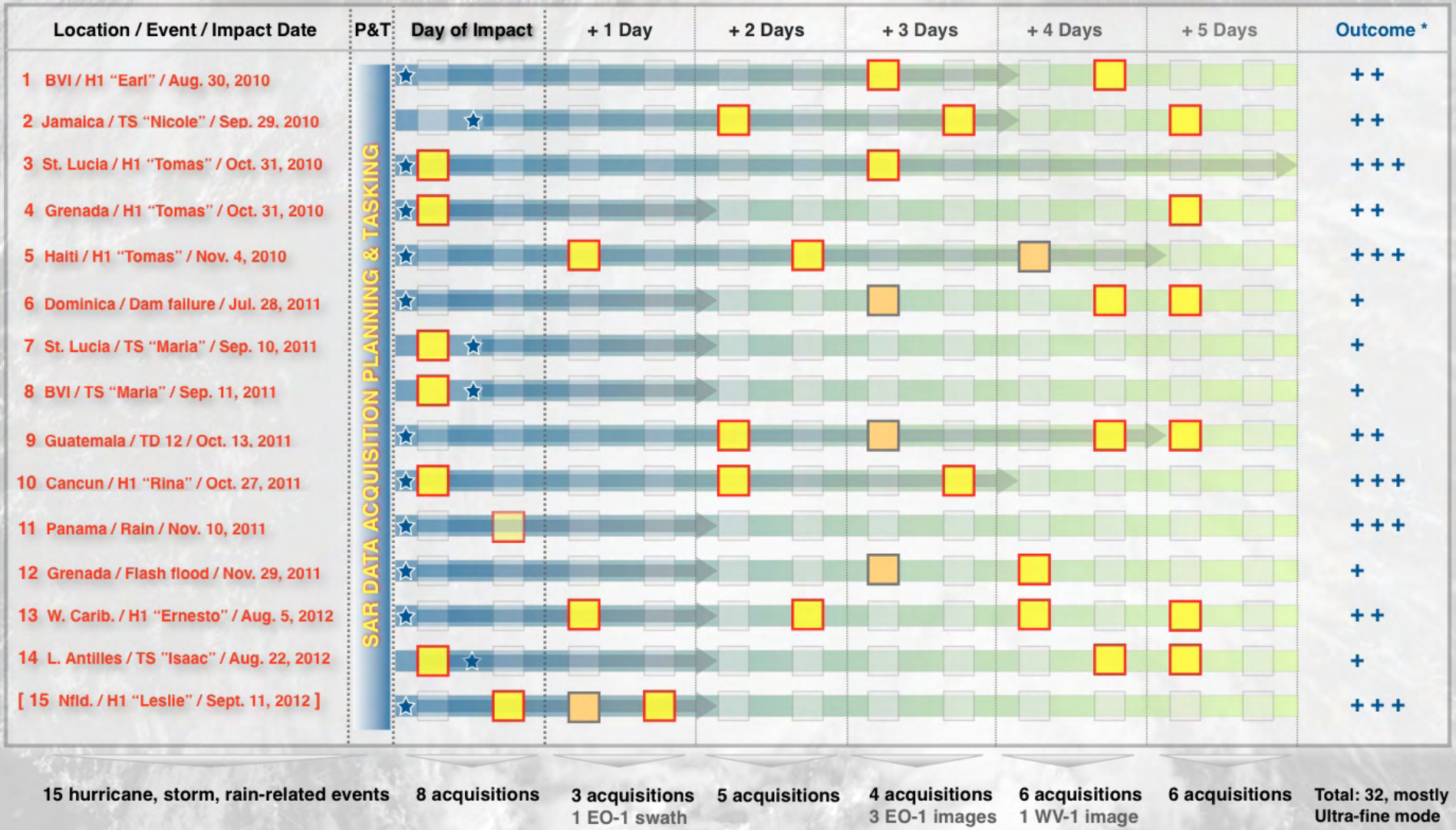
# Legend of Matrix Table



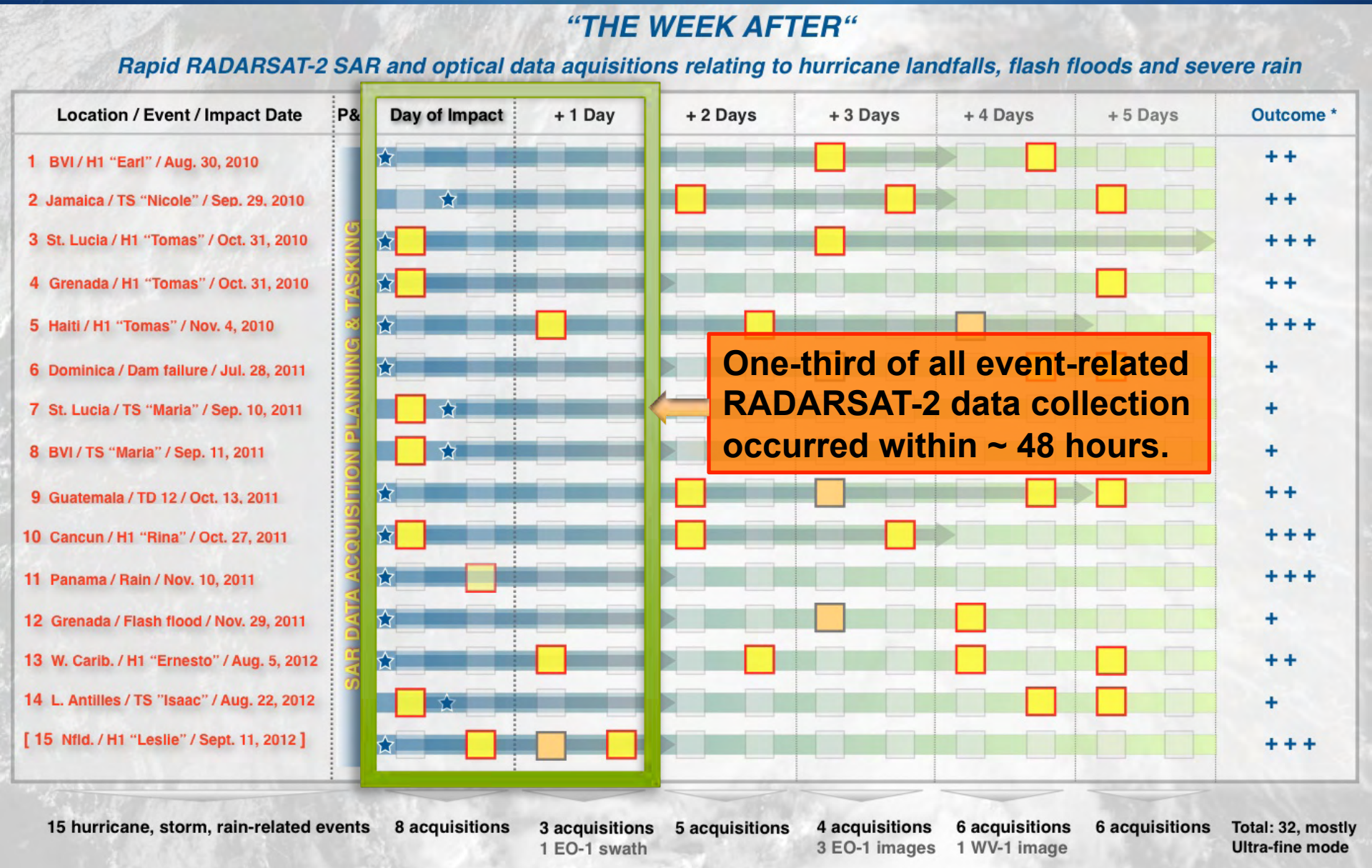
# Matrix of Sample Locations, Event Latency, EO Time Windows, Actual EO Data Acquisitions, and Outcome

## "THE WEEK AFTER"

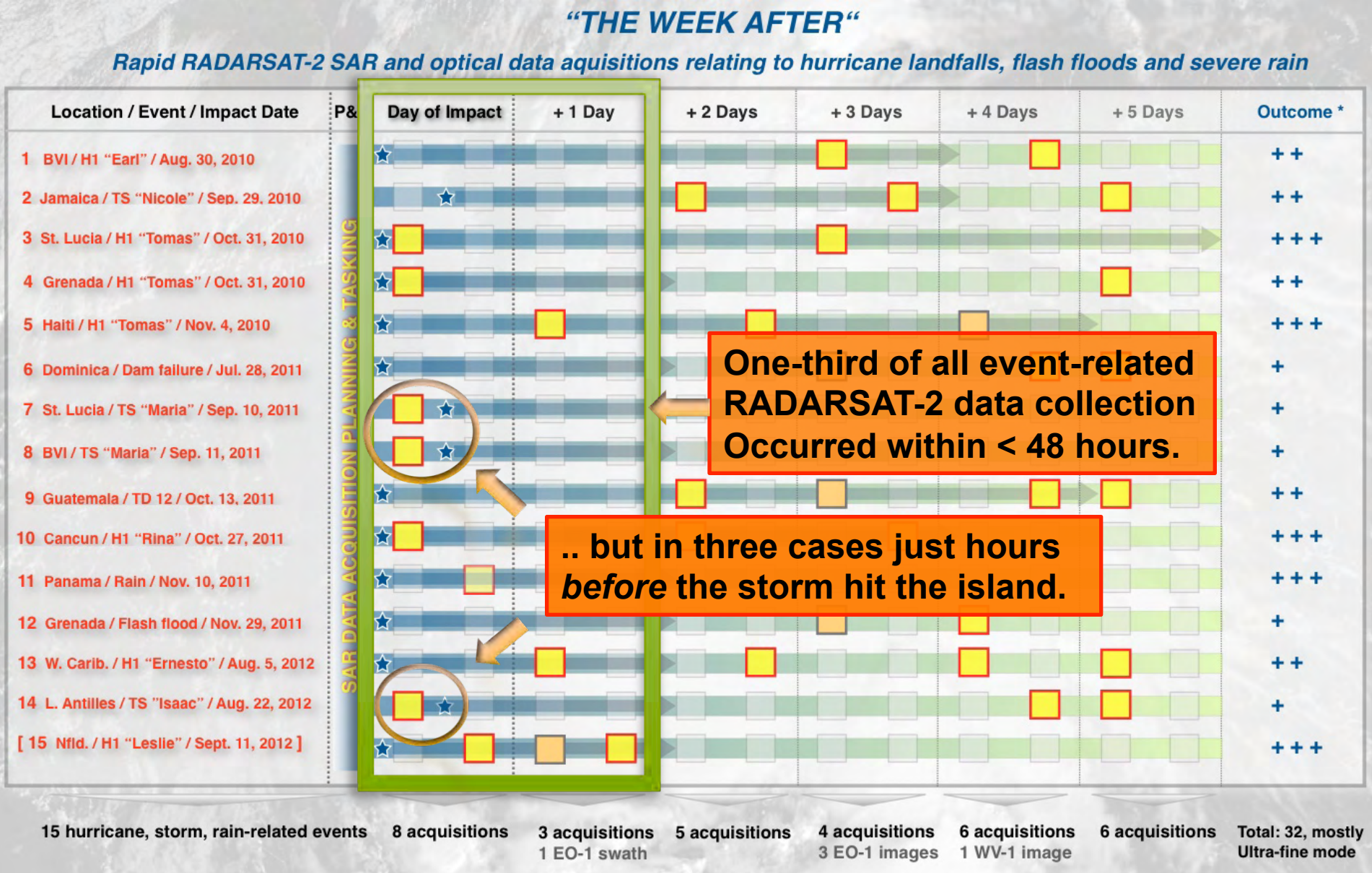
*Rapid RADARSAT-2 SAR and optical data aquisitions relating to hurricane landfalls, flash floods and severe rain*



# Matrix of Sample Locations, Event Latency, EO Time Windows, Actual EO Data Acquisitions, and Outcome



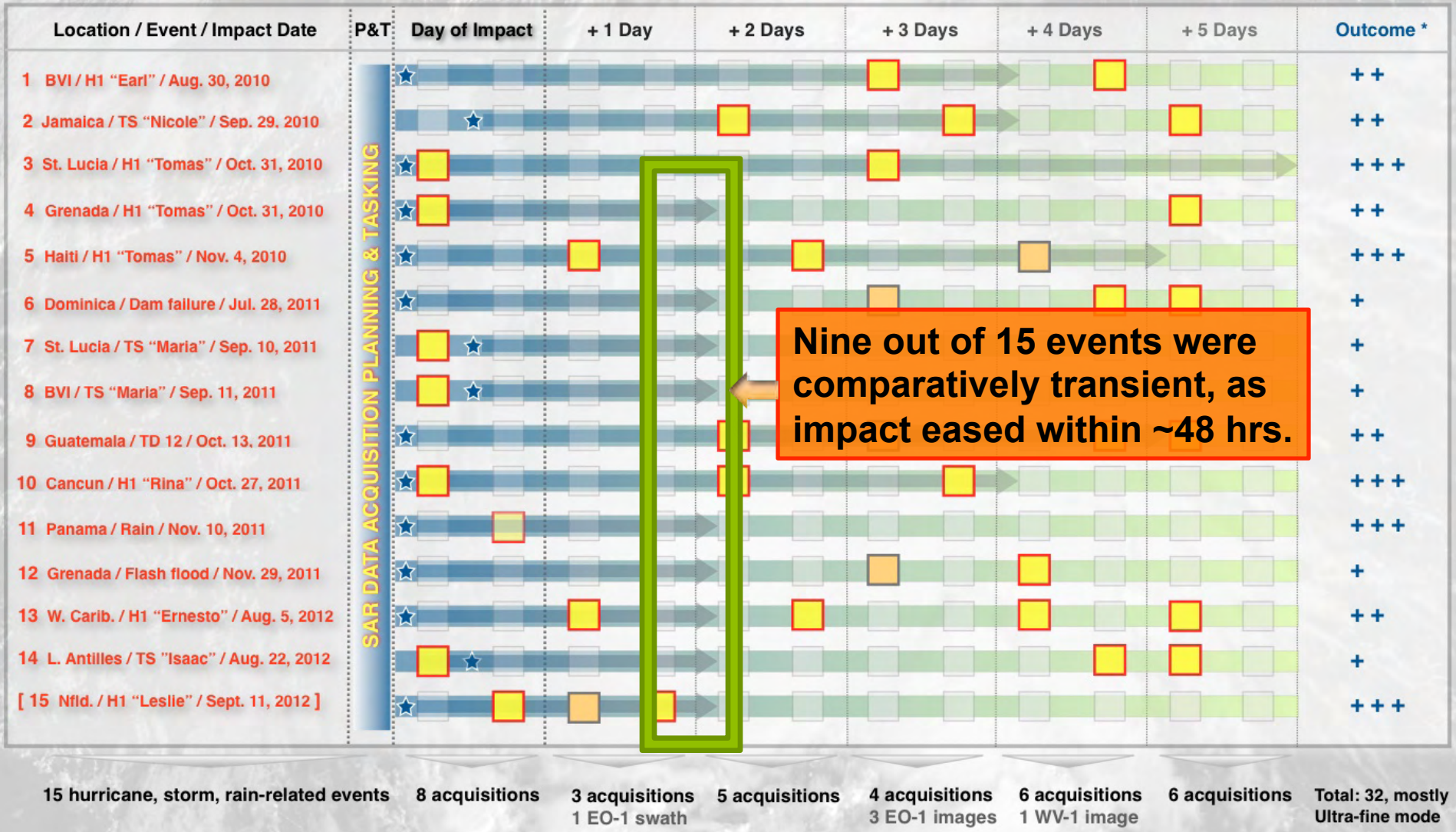
# Matrix of Sample Locations, Event Latency, EO Time Windows, Actual EO Data Acquisitions, and Outcome



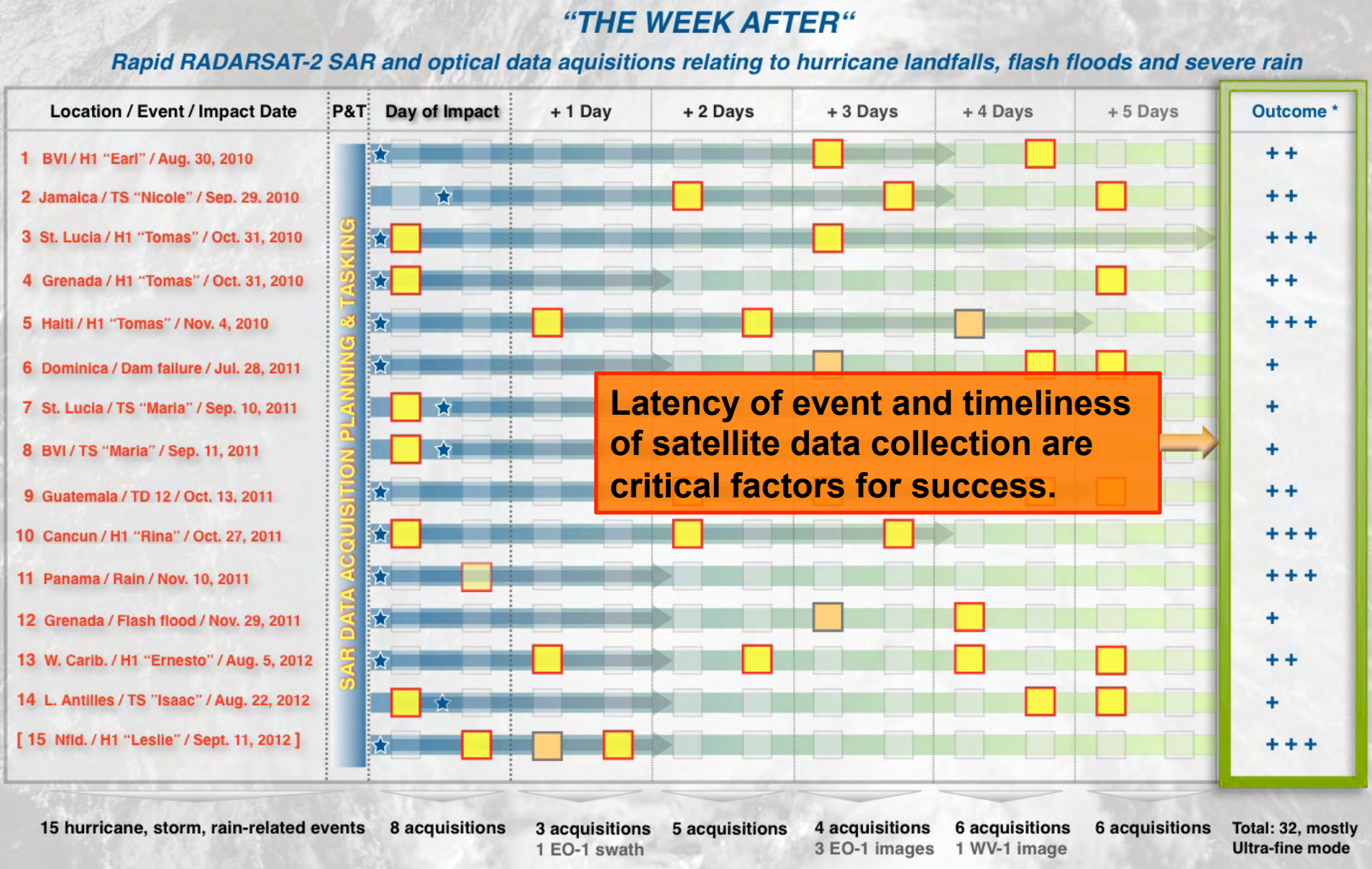
# Matrix of Sample Locations, Event Latency, EO Time Windows, Actual EO Data Acquisitions, and Outcome

## "THE WEEK AFTER"

*Rapid RADARSAT-2 SAR and optical data aquisitions relating to hurricane landfalls, flash floods and severe rain*



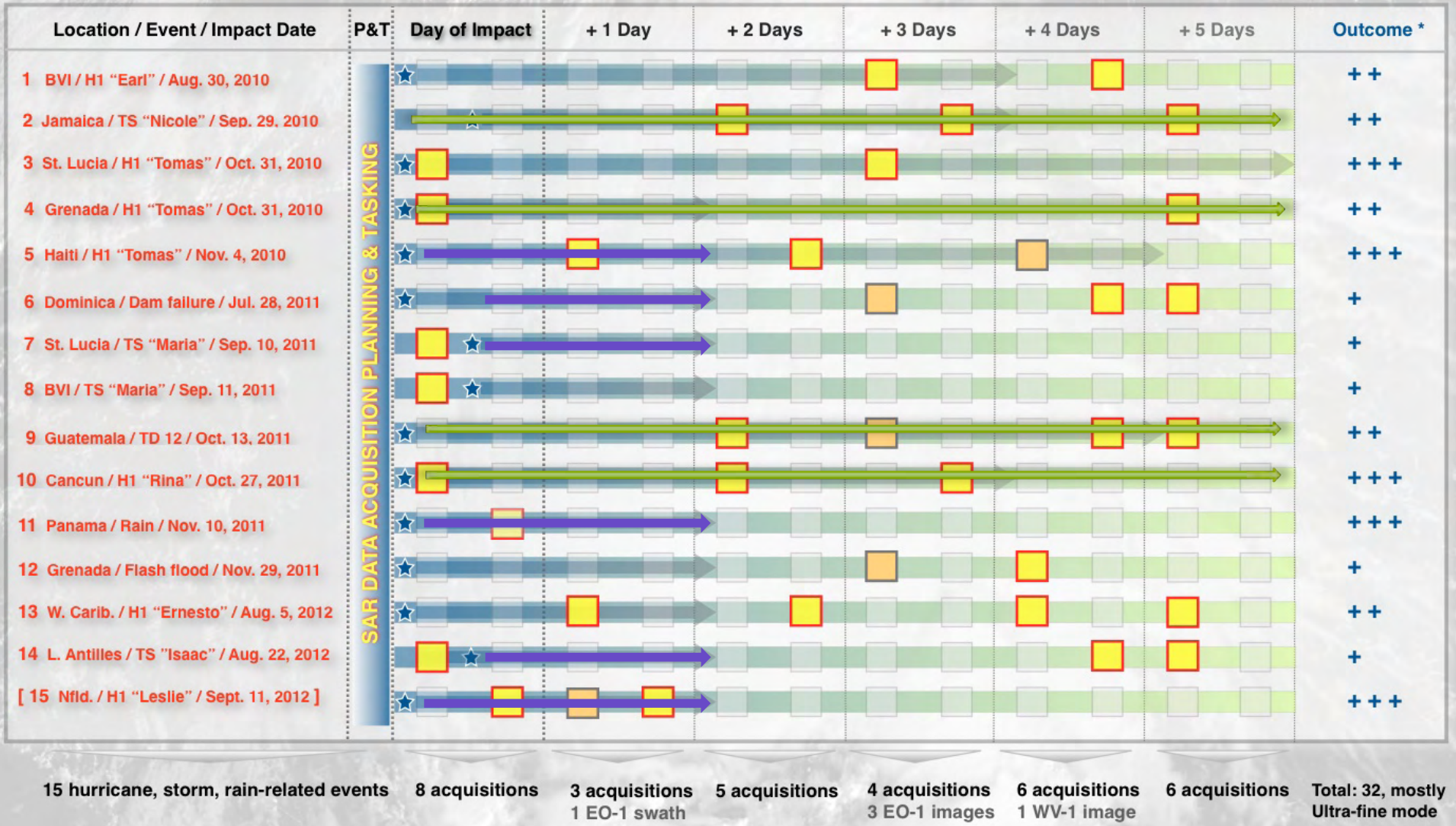
# Matrix of Sample Locations, Event Latency, EO Time Windows, Actual EO Data Acquisitions, and Outcome



# Matrix of Sample Locations, Event Latency, EO Time Windows, Actual EO Data Acquisitions, and Outcome

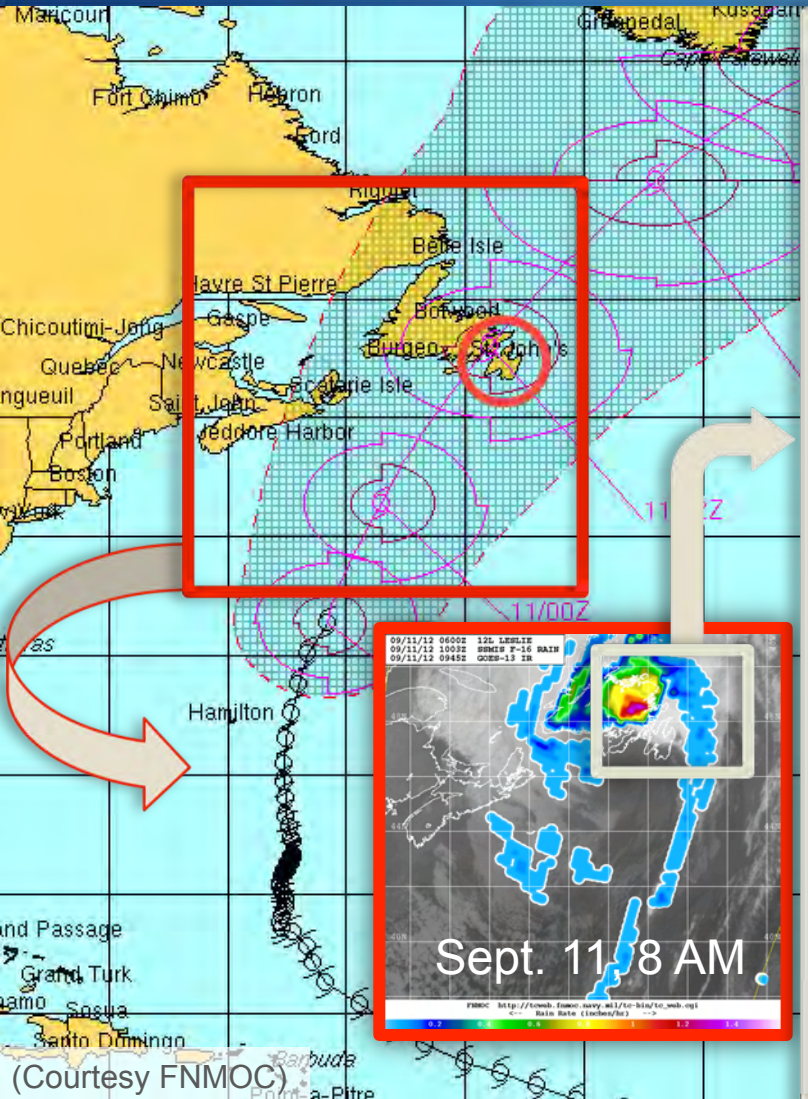
## "THE WEEK AFTER"

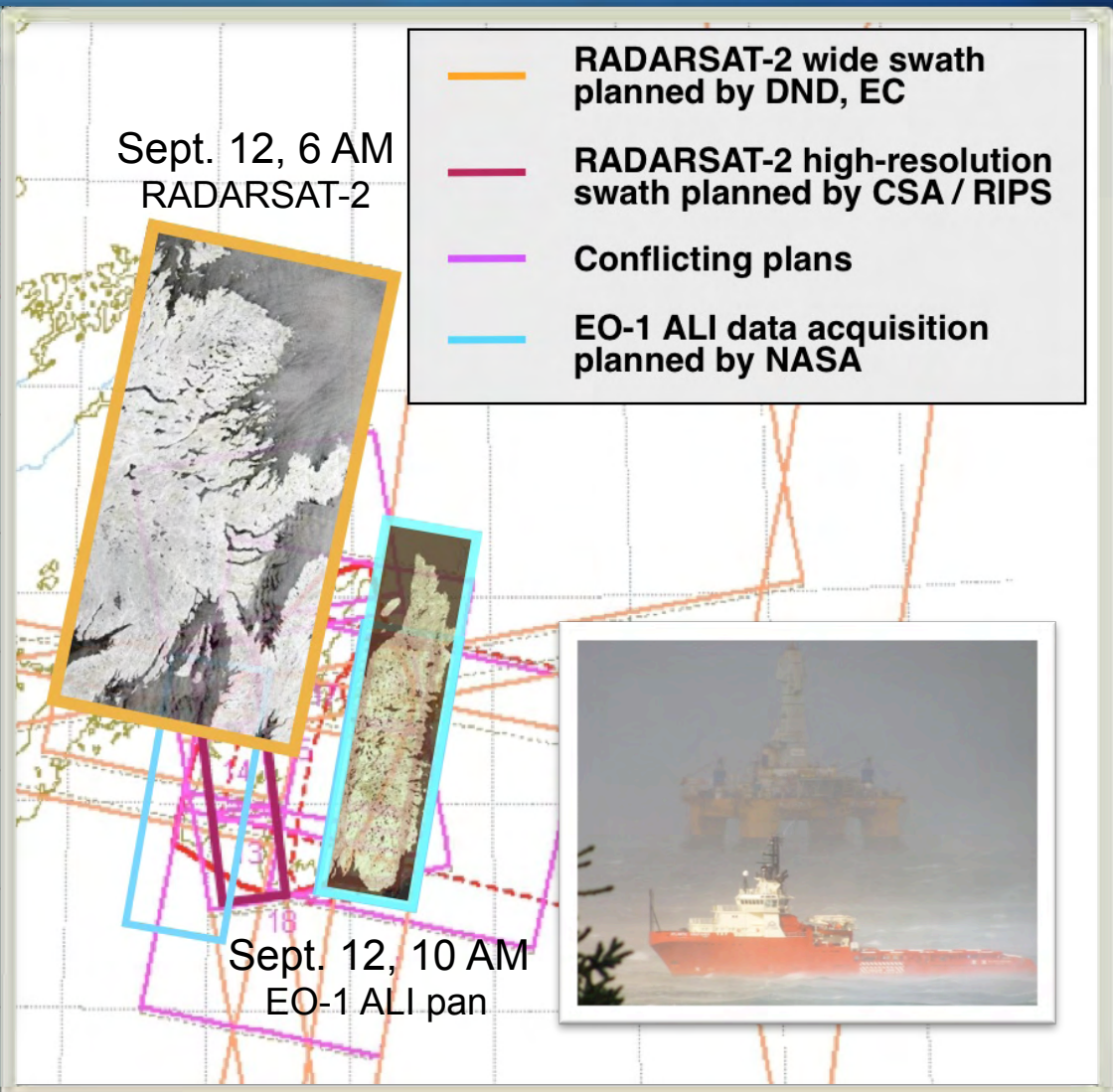
*Rapid RADARSAT-2 SAR and optical data aquisitions relating to hurricane landfalls, flash floods and severe rain*




| 15 hurricane, storm, rain-related events | 8 acquisitions | 3 acquisitions<br>1 EO-1 swath | 5 acquisitions | 4 acquisitions<br>3 EO-1 images | 6 acquisitions<br>1 WV-1 image | 6 acquisitions | Total: 32, mostly<br>Ultra-fine mode |
|---|---|---|---|---|---|---|---|

# Hurricane *Leslie* Impact in Newfoundland, Canada: Timely RADARSAT-2 SAR and EO-1 ALI Response



# Summary of CSDP 'Time-line' Analysis

## RADARSAT-2 Response

- Nearly conflict-free planning for 32 SAR acquisition events
- 9 of 15 events (60%) covered during first 48 hours of impact
- 20% during Day 2 and Day 3 after impact
- 20% during Day 4 and Day 5

## Event Latency

- Most hurricane impacts are transient and difficult to 'capture' with hi-res sat data
- Severe hurricanes and rainfall events leave more lasting impact detectable from space
- First 48 hours seem most critical for effective and helpful EO response

# Conclusions

## CSDP results are case-specific, but offer helpful insights

- Pre-emptive planning essential for collecting SAR data close to event impact
- Transient nature, *e.g.* flash floods, poses challenges for effective EO data collection
- Timely RADARSAT-2 data
- Events of short-duration are presently a challenge
- Coordinated EO data planning and collection highly desirable
- Timely coverage (*e.g.* first 48 hours) is critical for most events and for EO success.
- Canadian Outlook: RADARSAT Constellation Mission (2016>) with daily coverage, 24 hour notice; 1 hour delivery.

# Rapid and Detailed RADARSAT-2 Data Collection for the Caribbean Satellite Disaster Pilot (CSDP)

## Practical Experience During the Hurricane Season in 2010, 2011 and 2012

By

**Dirk Werle[1], Guy Aubé[2], Guy Séguin[2] and Stuart Frye[3]**

[1] Ærde Environmental Research, Halifax, NS, Canada, E-mail: dwerle @ ca.inter.net

[2] Canadian Space Agency, Saint-Hubert, QC, Canada [3] NASA/GSFC/SGT, Greenbelt, MD, USA